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The Impact of AI-Enabled Climate Intelligence on Agricultural Adaptation and Farm Resilience

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ABSTRACT

This study examined the impact of climate intelligence, integrated with an artificial intelligence (AI) system, on agricultural adaptation and farm resilience. The research used a quantitative cross-sectional design with a structured questionnaire using a 5-point Likert scale, along with qualitative questions, and a sample of 300 Farmers and Agricultural Stakeholders. The climate intelligence, agricultural adaptation, and farm resilience parameters were determined using AI. The data were analyzed using descriptive statistics, reliability analysis, Pearson correlation, and regression analysis. AI climate intelligence was strongly and positively correlated with both agricultural adaptation ($r = 0.68$, $p < .001$) and farm resilience ($r = 0.64$, $p < .001$). Regression analysis found that AI-based climate intelligence was significantly related to agricultural adaptation ($\beta = 0.68$, $p < .001$, $R^2 = .462$) and farm resilience ($\beta = 0.64$, $p < .001$, $R^2 = .410$).

Keywords: *Agricultural Adaptation, Artificial Intelligence, Climate Intelligence, Farm Resilience, Predictive Analytics, Smart Agriculture.*

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Introduction

Climate variability, warming, irregular precipitation, droughts, floods, heat stress, and other climate drivers are finding their way into the agricultural systems, leading to threats to productivity and livelihoods at the farm level. As a consequence, adaptive agricultural systems, which are able to predict climate risks and adapt production in time, are increasingly needed. Artificial Intelligence (AI) has emerged as a promising solution for enhancing agricultural sustainability over the past few years by leveraging predictive analytics, smart monitoring, precision farming, and decision-making processes grounded in data (Sharma et al., 2025; Mmbando, 2025).

Climate intelligence that leverages the power of AI technology is a new way to make agricultural decision-making faster, better and more accurate. Machine learning, remote sensing, Internet of Things (IoT) devices, predictive modelling, intelligent decision support can assist the farmer in his agricultural input management, irrigation planning, assessment of climate risks, crop condition monitoring and yield forecasting. It has been suggested in recent works (Mmbando, 2025; Nawaz & Babar, 2024) that AI and remote sensing can further enhance the climate-smart agriculture framework by augmenting the assessment of the risks, optimizing resource utilization, crop modeling, and farm management decisions. AI systems can also be used to predict drought, rain, pest risks, crop stress, and so on, allowing growers to act before they cause major losses due to climate change.

AI applications in age have increased in number, there are key areas of research that need attention to better understand how AI can help in real-world ag adaptations and farm resilience. The existing research is about individual technological solutions such as monitoring of crops, predicting the crop yield, precision irrigation, disease detection, etc., and not about the overall ability of the AI-powered climate intelligence to manage uncertainty caused by climate. The current research is on individual technological applications such as monitoring of crops, predicting the crop yield, precision irrigation, disease detection or others, but not the overall ability of the AI-powered climate intelligence to manage climate related uncertainty. Even though recent scholarship reveals a potential for AI to help build agricultural resilience, several factors still need to be taken into account when assessing the utility and effectiveness of AI, including access to technology, digital literacy, infrastructure, access to data, affordability, and how the information generated by AI is interpreted (Roy et al., 2025; Sharma et al., 2025). Furthermore, the literature is expanding, and there is a need to consider more than merely the accuracy of predictions in studies of adaptation by AI.

Background of the Study

One of the uncertainties of agricultural production which may be related to Climate Change is: how will it affect temperature, rainfall, soil moisture, pest and disease dynamics, farm income and crop growth? Due to variable climate, farmers are under increasing pressure to change their crop selection, water allocation, plantings dates, and input usage and risk management strategies. Results of recent agricultural research suggest that farmer's adaptation strategies have the potential to enhance their resilience through exposure to climatic shocks and bolster their adaptation capacity but would depend on the farming context and farm-level climatic hazard exposure experienced by farmers (Tunio et al., 2024).

Go to the root of the climate intelligence production problem and find cutting-edge solutions with AI. AI-driven predictive models can be coupled with meteorological data, crop growth parameters, soil conditions, and data from different sensors, which can give comprehensive information vital for agricultural decisions. Applied to precision irrigation, crop-health monitoring and yield prediction, pest detection and monitoring, resource optimisation, and climate-risk assessment these technologies can contribute. AI has emerged as a pivotal component for climate-smart agriculture, with predictive analytics and intelligent technologies playing a crucial role in optimizing resource utilization and supporting farmers in adapting to climatic changes (Nawaz & Babar, 2024; Mmbando, 2025; Roy et al., 2025).

The capacity of an agricultural enterprise or system to cope with shock, adapt to change, bounce back from disruption and continue to produce and be profitable is farm resilience. AI-driven climate intelligence can help to achieve this resilience by offering early warnings, pinpointing emerging risks, predicting production conditions and aiding the evidence-based decision-making process. AI and digital agricultural technologies have been recently found to be associated with better resource management, reduction of climatic risks, crop resilience, and sustainable agricultural production (Mandour et al., 2025; Sharma et al., 2025). The potential of AI relies on the technology and digital skills, infrastructure and institutional support that farmers have.

Research Objectives

1. To explore how much climate intelligence farmers and agricultural stakeholders are using that leverages AI, including climate forecasting, predictive analytics, early-warning information and intelligent decision-support systems.
2. To evaluate how AI-driven climate information and knowledge relate to agricultural adaptation, focusing on the farmers' capacity to adapt production methods, mitigate climate risks, and make timely decisions on agriculture.
3. To assess the effects of AI powered climate intelligence on the resilience of farms, specifically farmers' ability to withstand climate shocks, continue agricultural production and rebuild from environmental shocks.

Research Questions

Q1. How do farmers and other agricultural stakeholders feel about the extent of AI-based climate intelligence?

Q2. What are the impacts of climate intelligence with AI on farmers' adaptation to climate variability and environmental risks?

Q3. How does AI-powered climate intelligence help farm to become more resilient and farmers to better prepare for and respond to climate risks?

Significance of the Study

The study is important as it adds to the body of research on the role of AI, climate adaptation and agricultural resilience. The latest studies reflect continued technological advancements for climate predictions, risk surveillance, precision agriculture, and decision-making support, and there is also evidence of ongoing disconnect between the technologies and tangible adaptation impacts. Considering AI-powered climate intelligence both from perspectives of agricultural adaptation and farm resilience, the study offers a holistic view of how intelligent technologies can help farmers act proactively when dealing with uncertainty associated with the climate. The results can support the understanding of the practical impacts of using AI-based climate information and help to improve the design of AI-based climate information systems that are more accessible, localized, and farmer-centred, which can be used by agricultural policy makers, extension services, technology developers, and development organisations. It is also relevant for developing economies where timely information about agriculture is especially critical due to climate vulnerability, resource constraints, and the presence of uneven digital infrastructure. The recent application of localised climate advisory through AI tools is an excellent example of the increasing practicality of this work for farmers' decision-making and resilience.

Literature Review

AI-Enabled Climate Intelligence in Agriculture

Climate intelligence is also increasingly a part of the digital agriculture agenda, as it enables agriculture to transform complex environmental and climatic information into a resource to inform decision making at the farm level, using AI. There are a number of different types of data, such as climate indicators, farm characteristics, weather observations, and socio-economic information, that can be used in a machine learning model to predict farmers' climate-smart agriculture behavior. Machine-learning models, in recent studies, have been found to capture the pattern of farmers' adaptation decisions and provide valuable predictions in choosing and planning for climate-smart practices, aiding decision-making (Sereke et al., 2024). In this context, the application of AI in agriculture goes beyond forecasting, and incorporates climate data into the decision-making process.

Additionally, recent research demonstrated that AI is more effective when integrated with other digital tools. The information obtained from the sensors in the IoT system combined with remote sensing and big data analytics and predictive models can deliver a continuous flow of information about weather, soil conditions, crop health and resource requirements. An integrated system can improve surveillance and allow for a more precise agricultural management, which can detect potential risks prior to their occurrence, thus avoiding substantial losses in agricultural production (El Bilali et al., 2025). AI-driven climate intelligence can, therefore, provide more localized and timely data to farmers for irrigation scheduling, crop planning, pest monitoring and managing resources.

Despite these developments, literature suggests that the adoption of AI in agriculture is not uniform and is unevenly distributed among agricultural communities. The digital infrastructure, affordability, connectivity, literacy and access to reliable data could be restricting for smallholder farmers. Recent studies on climate-adaptive artificial intelligence stress the need for technology solutions to consider the local needs of the small farmers and not assume equal access to sophisticated digital technology (Klerkx et al., 2025). The importance of this is it's not a matter of the predictive power of AI systems, it's also about understanding, access and application of the information that they produce generated by AI systems by farmers.

Impact of AI on agricultural adaptation

Agricultural adaptation refers to changes in agricultural practices, use of resources, production decisions and risk management strategies in response to changes in climate. AI can help identify and assess climate risks and offer predictive analytics that help farmers plan and respond to climate shocks and stresses. Machine learning research evidence reveals that climate-smart agricultural practices can be predicted based on characteristics of the farms, socioeconomic and climatic factors, thus paving the way for optimization of adaptation planning and targeted interventions (Sereke et al., 2024). AI can be used to enhance adaptation capabilities by mitigating the uncertainty and helping farmers choose their adaptation strategies based on the expected climatic conditions.

Timely climate information also strengthens the digital intelligence-adaptation linkages. Farmers require accurate, easily understood and relevant information about how to improve the productivity of their farms by changing their planting schedules, irrigation methods, varieties and input management. The recent study in Pakistan confirms the importance of climate knowledge and adaptive capacity for driving adaptation practices and the role of access to farming technologies and climate-information resources to strengthen adaptation practices in the face of climate challenges (Ali et al., 2024).

However, the latest research shows a disconnect between the development of AI systems and the existing evidence of the outcomes of AI adaptation. The study by Jumadi et al. (2026) conducted in 2026 on a systematic evidence mapping review showed that the majority of research on AI applications for agricultural climate adaptation are still centered on hazard prediction and monitoring, and there are relatively few studies relating to agricultural vulnerability and to the outcomes of agricultural adaptation and maladaptation. This imbalance indicates that while high predictive performance is not necessarily equal to good adaptation at the farm level. The potential of AI to improve farmers' adaptation to agriculture and reduce the risks climate change poses to agriculture, therefore, requires more empirical study. This study investigates how agricultural adaptation is a direct consequence of using AI-enabled climate intelligence.

AI and Climate Intelligence and Farm Resilience

Farm resilience is the ability of agricultural systems to resist environmental shocks, endure long droughts and/or floods, recover from shocks and disruptions, and remain productive. These can be addressed with digital technologies such as real-time monitoring, predictive analytics, precision resource management and risk assessment. Empirical studies in recent years in China have shown that digital agriculture, such as AI, IoT, big data analysis and other technologies, can enhance the capacity of farmers to face short- and medium-term climate shocks and respond to climate changes in the medium to long term to support their climate resilience (Niu et al., 2025). The implications of these findings are that digital intelligence would be a cross cutting capability which may be aligned with information, resource management and adaptive decision making.

AI solutions can also contribute to resilience in improving the efficiency and timing of agricultural actions. Predictive analytics can alert farmers and help them take preventative action if they see potential issues like crop stress, weather events, pest problems, or resource limitations. Certain aspects of data-driven production decision making, resource management and mitigating negative impacts of disruptive technologies can be facilitated by the use of AI and other digital technologies in the context of resilience of the agriculture sector to the stresses of climate change (Bashir et al., 2025). In essence, AI climate intelligence can be seen as a tool to help farmers put climate information into action, reduce their vulnerability, and create more sustainable farms. The use of AI for climate intelligence could be viewed as a transformation of environmental information into action before events in order to reduce vulnerability and continuity of farm operations.

Recent studies on digital technologies for climate-smart agriculture show that technological infrastructure, digital literacy, and connectivity are key requirements for enabling and successful use of digital technologies, particularly farmers belonging to the smallholder category. The literature available suggests that AI climate intelligence has a lot to offer to enhance farm resilience, but empirical studies should investigate if the use of AI climate intelligence by farmers is linked to farm resilience. This research project explores the possibilities of AI tools to leverage agricultural adaptation and farm resilience in the context of Climate Intelligence.

Research Methodology

Research Design

The study used a quantitative research approach with the cross-sectional design to examine the impact of AI-enabled climate intelligence on agricultural adaptation and farm resilience. A quantitative approach was suitable for the study to measure the perceptions and experiences of the respondents in the structured questionnaire items and test the relationships between the study variables statistically. Cross sectional design allowed the researcher to gather data from the participants at one time and assess the associations of AI-based climate intelligence, agricultural adaptation, and farm resilience in the same period.

Population of the Study

Population included farmers and agricultural stakeholders engaged in crop production and agricultural decision making. Target participants were those who had experience in farming practices, agricultural technologies, supply of information about the weather, climate-related decision-making, and digital agricultural tools. This population was identified because they are the individuals that directly experience climate risks and have decisions to make about crops, irrigation, input usage, crop selection and natural resource management. Agricultural stakeholders with relevant technological and/or climate expertise were also deemed appropriate as they could offer informed comments on AI-based climate intelligence and its role in agricultural adaptation measures and farm resilience.

Sample Size and Sampling Technique

The number of respondents for the study was 300. The participants were selected using the purposive sampling approach and those who had relevance and experience in relation to agricultural production, climate information, digital technologies or climate adaptation were identified. The sampling approach enabled meaningful answers to the questions regarding AI-enabled climate intelligence and its contribution to agricultural decision making. The respondents were accessed by the farming community, agricultural networks, agricultural extension and agricultural technology groups. The number of observations ($n = 300$) was adequate for descriptive statistics, reliability checks, correlation analysis and regression analysis.

Data Collection Procedure

Structured questionnaire was used to collect primary data. The questionnaire was developed based on the objectives and conceptual framework of the study. The instrument was pretested for unclear, repetitive or difficult items prior to the main survey. A few respondents who had characteristics of the target population were selected and a pilot assessment conducted. Input received from the pilot assessment was taken into consideration to improve the questionnaire. Questionnaires were then sent to the selected participants after the finalization. Participants were briefed on the objective of the study and the voluntary participation. Before entering the data into the statistical software for analysis, the completed questionnaires were examined for completeness.

Research Instrument

There were two main sections of the questionnaire. The first section was the demographic and agricultural data of the respondents such as gender, age, educational level, years of farming experience, farm size, and exposure to agricultural technologies. The second section included the assessment of the three major constructs of AI-enabled climate intelligence, agricultural adaptation, and agricultural farm resilience. All substantive items were presented using a five point Likert scale ranging from strongly agree (5) to strongly disagree (1). The response format, Likert-scales, allowed participants to report how they agree or disagree with statements related to the availability, usefulness and use of AI climate intelligence and its impact on agriculture.

Data Analysis

Collected data were coded and analysed by SPSS. Descriptive statistics such as frequencies, percentages, means and standard deviations were computed to describe the demographic characteristics of the respondents and the overall levels of the study variables. Pearson correlation analysis was performed to assess the direction and the amplitude of the correlations between AI-enabled climate intelligence, agricultural adaptation and farm resilience. Multiple regression analysis was employed to explore the predictive power of AI-enabled climate intelligence on a) agricultural adaptation and b) farm resilience. Two regression models were created. The two models looked at the impact of AI climate intelligence on agricultural adaptation and farm resilience. Analysis reported: R, R^2, adjusted R^2, beta, standard errors, t and significance levels. The statistical significance was determined by 0.05 significance level.

Results and Analysis

Descriptive Statistics

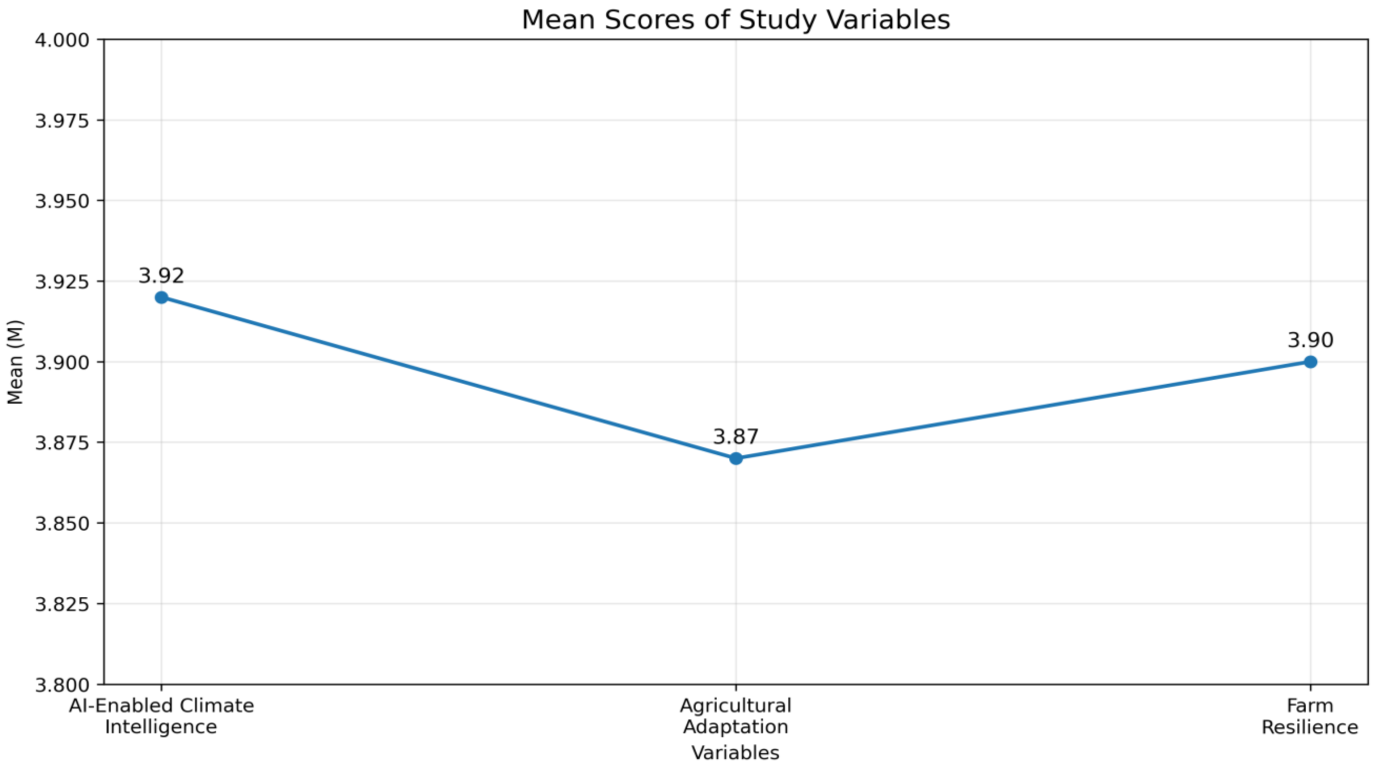
The descriptive analysis was conducted to determine the overall level of AI-enabled climate intelligence, agricultural adaptation, and farm resilience among the respondents.

Table 1: *Descriptive Statistics of Study Variables*

Variables	N	Mean (M)	Standard Deviation (SD)
AI-Enabled Climate Intelligence	300	3.92	0.71
Agricultural Adaptation	300	3.87	0.74
Farm Resilience	300	3.90	0.70

Results presented in Table 1 indicate that AI enabled climate intelligence had the highest mean score (M = 3.92, SD = 0.71) of the three variables. The findings suggested that the overall attitudes of the respondents were positive concerning the utilization of AI-supported climate information for agricultural decision-making. The meanest score (M = 3.90, SD = 0.70) was achieved by farm resilience. This finding indicated that overall the riders of farmers are not entirely unsure about their adaptation capability in their farms when it comes to climate changes and climate disruption. The study results revealed that the farmers could sustain farming activities, manage environmental disturbances, cope and adjust their farming methods to changing situations. The mean level of agricultural adaptation was 3.87 (SD = 0.74) which was relatively high. Most of the samples answered that they had adjusted to the changes in climate conditions in their agricultural activities. These changes included crop selection, changes in planting schedules, irrigation management, input usage and implementation of climate smart strategies.

Figure 1: *Descriptive Statistics of Study Variables*



Correlation Analysis

Pearson correlation analysis was conducted to examine the relationships among AI-enabled climate intelligence, agricultural adaptation, and farm resilience.

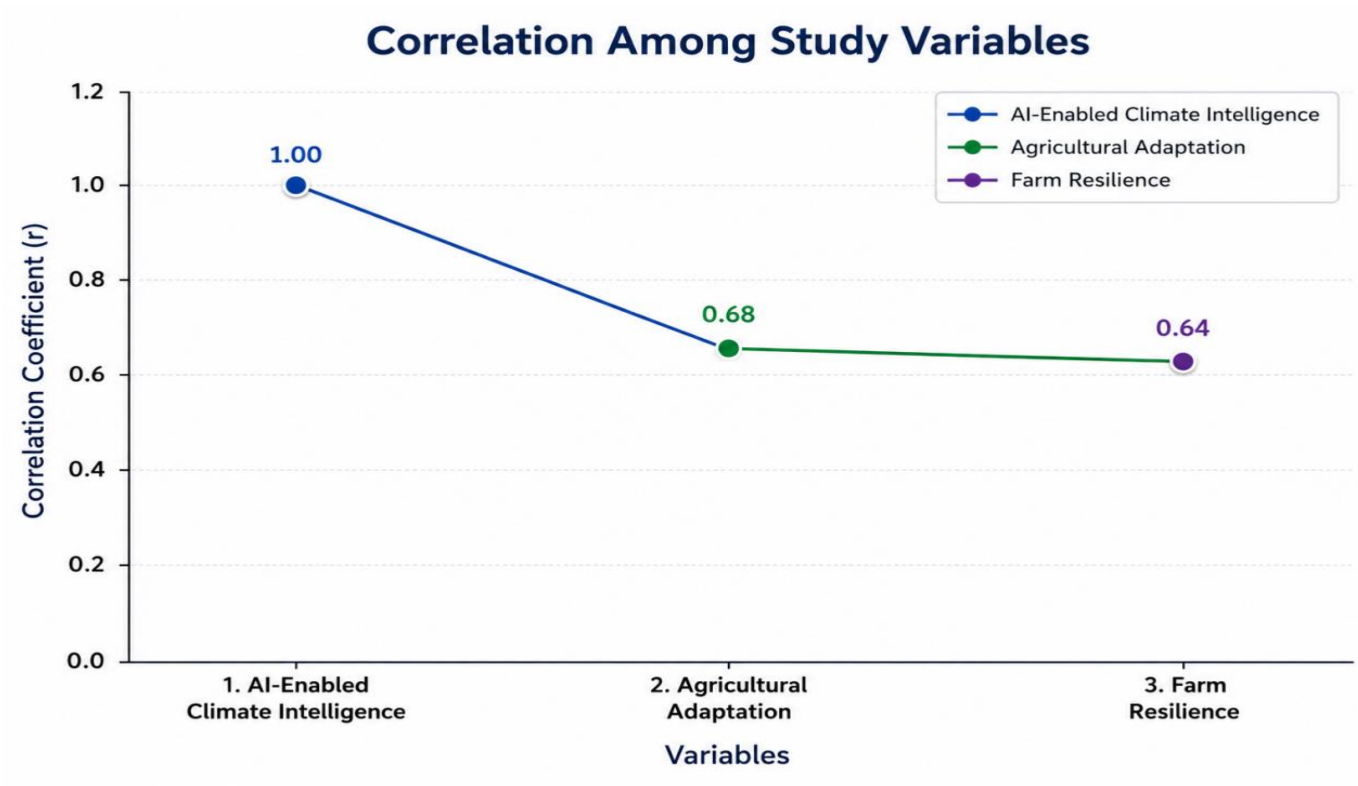
Table 2: *Pearson Correlation Analysis of Study Variables*

Variables	1	2	3
1. AI-Enabled Climate Intelligence	1.00		
2. Agricultural Adaptation	0.68	1.00	
3. Farm Resilience	0.64	0.72	1.00

p < .001

As is evident from the results in Table 3, there was a high positive correlation between AI-based Climate Intelligence and Agriculture Adaptation ($r = 0.68$, $p < .001$). This finding suggested that those who felt they had more access to and use of AI-based climate intelligence also had stronger agricultural adaptation. The connection indicated that farmers' adaptation to climate changes through a change in production methods were related to the use of AI generated climate forecasts, predictive information and intelligent decision support. AI climate intelligence has a significant and positive correlation with farm resilience ($r = 0.64$, $p < .001$). The result showed that farms with higher perceived use of AI-empowered climate intelligence had higher perceived farm resilience. Agricultural adaptation was also highly and positively correlated with farm resilience ($r = 0.72$, $p < .001$). The result indicated that generally, the higher the adaptation practices experienced by the farmers, the higher the perception of farm resilience. The results suggested that adaptation and resilience were closely related agricultural outcomes because the capacity to adapt to farming practices may be a way to enhance the ability to respond to and recover from climate induced disruptions.

Figure 2: *Pearson Correlation Analysis of Study Variables*



Regression Analysis: AI-Enabled Climate Intelligence and Agricultural Adaptation

Multiple regression analysis was conducted to determine whether AI-enabled climate intelligence significantly predicted agricultural adaptation.

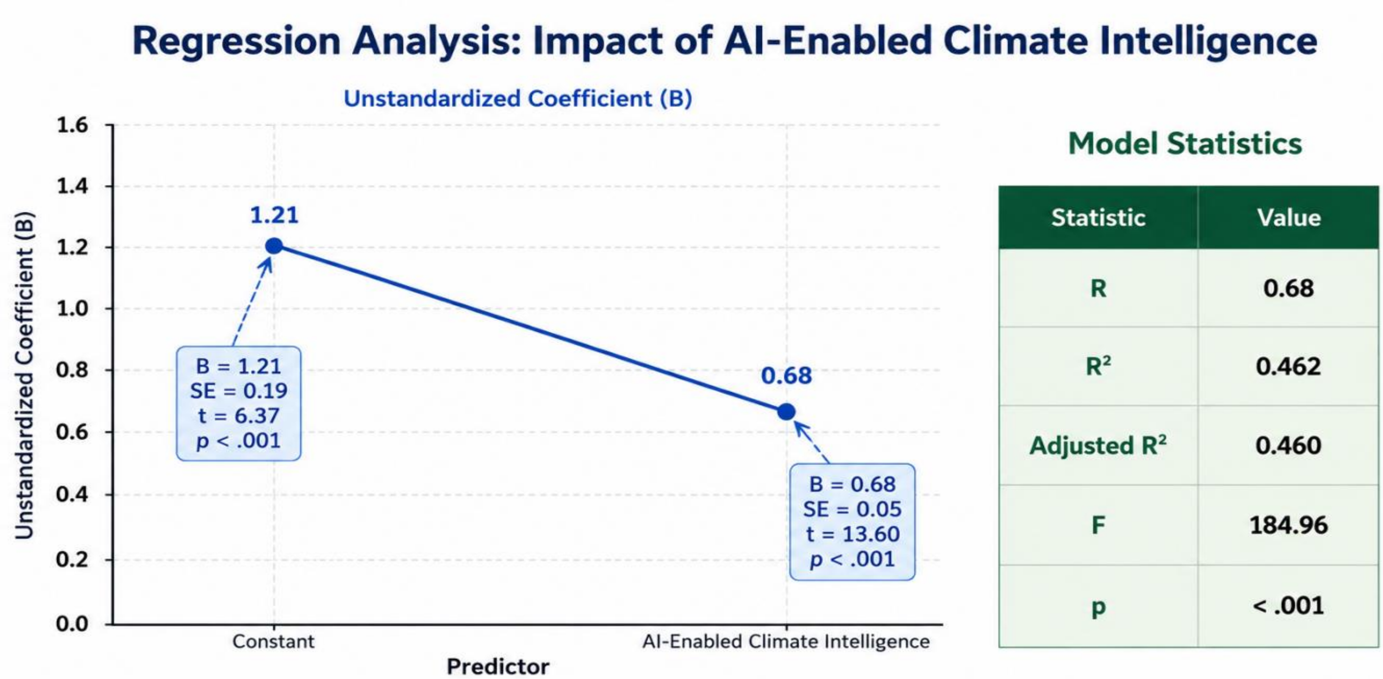
Table 3: *Regression Analysis of AI-Enabled Climate Intelligence on Agricultural Adaptation*

Predictor	B	Std. Error	Beta (β)	t	p
Constant	1.21	0.19	—	6.37	<.001
AI-Enabled Climate Intelligence	0.68	0.05	0.68	13.60	<.001

Model Statistics	Value
R	0.68
R^2	0.462
Adjusted R^2	0.460
F	184.96
p	<.001

Table 4 demonstrated that the regression results significantly predicted the agriculture adaptation using AI enabled climate intelligence ($\beta = 0.68$, $p < .001$). A positive beta coefficient meant that higher AI climate intelligence scores were related to higher agricultural adaptation scores. The t-value of 13.60 also showed that the predictor contributed significantly to the agricultural adaptation. The resulting model had an R^2 of 0.462, showing that the AI climate intelligence statistically accounted for about 46.2% of the variation in agricultural adaptation. The adjusted R^2 value was 0.460 which was not far away from the R2 and showed the explanatory power of the model did not change significantly when adjusted. The overall F-statistic was 184.96 with p< .001, which means that the regression model was statistically significant as a whole. The positive regression coefficient also suggested that climate information with AI was linked to pro-active responses to agriculture.

Figure 3: *Regression Analysis of AI-Enabled Climate Intelligence on Agricultural Adaptation*



Regression Analysis: AI-Enabled Climate Intelligence and Farm Resilience

A second regression model was estimated to assess the relationship between AI-enabled climate intelligence and farm resilience

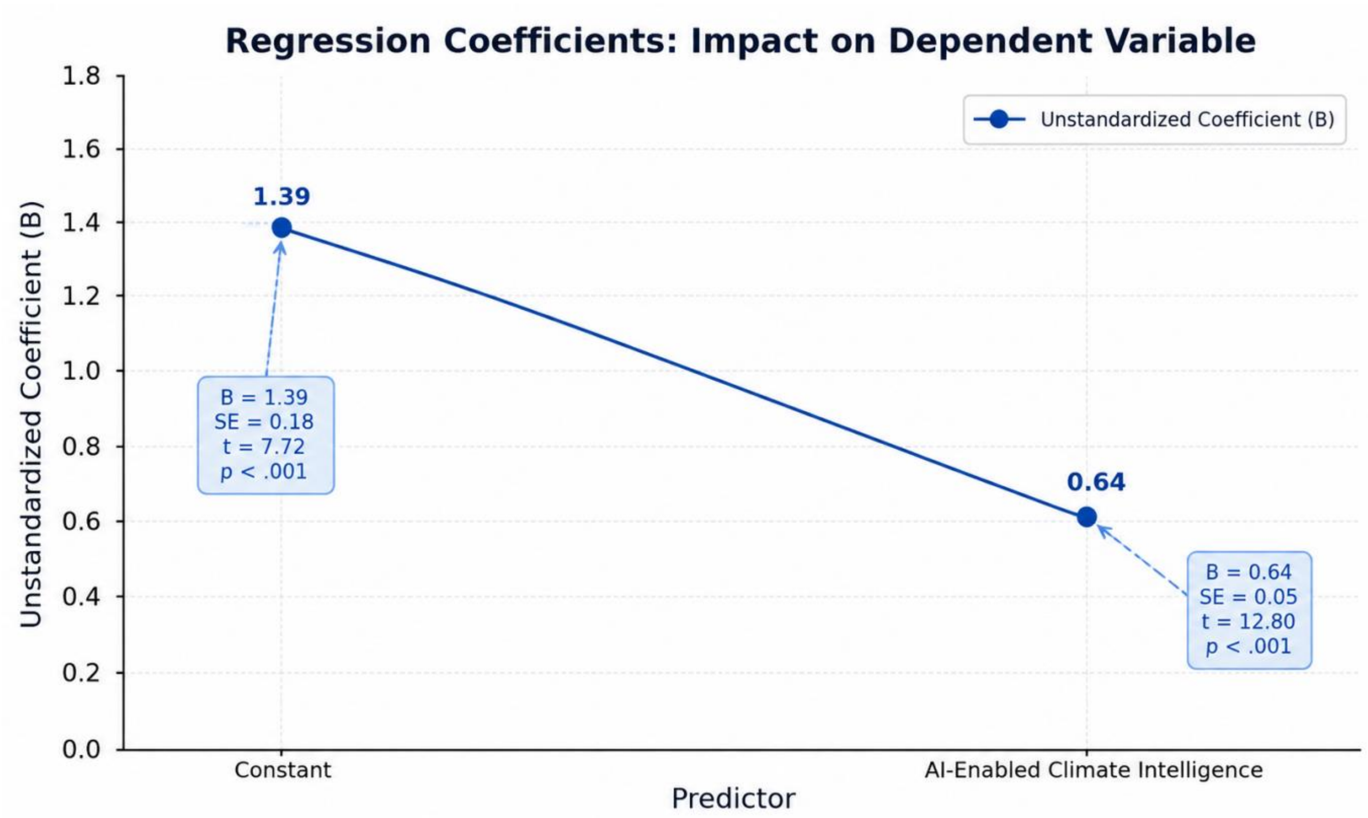
Table 4: *Regression Analysis of AI-Enabled Climate Intelligence on Farm Resilience*

Predictor	B	Std. Error	Beta (β)	t	p
Constant	1.39	0.18	—	7.72	<.001
AI-Enabled Climate Intelligence	0.64	0.05	0.64	12.80	<.001

Model Statistics	Value
R	0.64
R^2	0.410
Adjusted R^2	0.408
F	163.84
p	<.001

Table 5 indicated that AI climate intelligence had a positive and statistically significant relationship with farm resilience ($\beta = 0.64$, $p < .001$). The standardized beta coefficient showed that climate intelligence, which uses AI, was a significant predictor of farm resilience. The t value was also determined to be 12.80, which was statistically significant relationship. The R^2 (coefficient of determination) for the model is 0.410, indicating that about 41.0% of the variability in farm resilience is explained by using AI-based climate intelligence. The adjusted R^2 value was adjusted to 0.408, which is close to the explanatory power that existed prior to the adjustment. The model level F-statistic equaled 163.84 (p< .001) which implied that the model was statistically significant. The results revealed that the AI-enabled climate intelligence had a strong predictive power as it came to the farm resilience among the respondents. The results also suggested that climate intelligence can be a tool to build resilience in the form of timely information, risk identification, predictive assessment and better agricultural decision making. It seemed that farmers who have higher access to intelligent climate information were more likely to be better prepared to deal with environmental disturbances and to sustain their farm operations.

Figure 4: *Regression Analysis of AI-Enabled Climate Intelligence on Farm Resilience*



Discussion

The focus may be on changing the discourse around agriculture and precision farming towards a climate management system based on data and numbers. AI-powered climate intelligence is not just a string of automated actions in the field of farming, it is a combination of climate monitoring, gathering environmental data, climate forecasting and data-informed decision-making systems which work together. Recent research has identified the following technical advantages of AI for climate-smart agriculture: machine learning and digital twins, predictive modeling, and intelligent decision-making support architectures will help make agriculture decisions adapt to climate change (Vishwakarma & Kumar, 2025; Nikhitha, 2025). From this perspective, AI's role in climate-sensitive agricultural production is becoming increasingly important for converting information into knowledge that can be used in farm management.

Results also show a shift in focus to new methods of prediction in agriculture adaptation. Traditional adaptation can be based on the farmer's previous adaptation strategy and responses to the climate they have seen, whereas the AI-based systems can assist in the early detection of possible climate risks. AI technologies have made some strides in agriculture in recent years, such as environmental sensing, machine learning, and real-time analysis to enhance the management of crops, water resources, and production planning (Dhanaraj et al., 2025; Thingujam et al., 2025). Climate intelligence can enhance adaptation information by taking into account the climatic conditions farmers faced in their production decisions, which can be done with the developments indicated. It implies that AI might have a part to play in making agriculture more anticipatory, thereby transitioning towards more information-driven and climate responsive agriculture that is more suited for the context of a locality.

The results also demonstrate the growing understanding of the process of farm resilience as a multi-faceted endeavor that relies on the information, technological competence, resource management and adaptive decision making capabilities of the farm. Digital technologies can support farmers to monitor environmental conditions, to optimize limited resources, track new challenges and to ensure production under variable climatic conditions. Many digital innovations can play a supporting role in climate adaptation and agricultural resilience when combined, as pointed out in some recent reviews: AI, system of instruments measuring Internet of Things (IoT), remote sensing, Geographic information systems (GIS) and system of advisories to be served from mobile devices (MAS) and big-data analysis. AI irrigation optimization, as demonstrated through recent studies, is a key area in advancing water scheduling and resource utilization toward climate smart farming.

Another important consideration is the connections between adaptation and resilience as technological intelligence is not a precondition to resilient farms. Farmers must be able to access the information and make the correct decisions regarding crops, irrigation, inputs, planting schedule and risk management. The evidence on agricultural adaptation research highlights both technological and socio-economic factors related to farmers' adaptability, while the evidence on Climate-Smart Agriculture research shows that institutional support and locally relevant interventions are important. Empirical research findings on agricultural adaptation reveal the important role of both technological and socioeconomic conditions in influencing the adaptability of farmers, and the evidence from research on climate-smart agriculture shows the importance of institutional support and locally appropriate interventions (Shah et al., 2026; Ullah et al., 2026). This perspective takes into account the skills of the farmer, and the institutional setting of the community in which they live, as well as the complexity of the technology.

Finally, future strategies should focus on shifting from experimentation with agro-climate intelligence based on AI to more context-specific and context-relevant implementation and measurable adaptation impacts, as suggested from the broader literature. A recent systematic evidence map showed that the research on agricultural AI is highly polarised, with a relatively small amount of studies evaluating the impacts of adaptation efforts downstream from agriculture, related to climate hazards (Jumadi et al., 2026). These findings resonate with other recent evidence from sub-Saharan Africa indicating that data, inadequate digital infrastructure, lack of technical capacity and governance challenges are important obstacles to measuring the resilience impact of AI. The evidence suggests that the main components of a successful AI-powered climate intelligence are the availability of local data, availability of accessible digital tools, local farmer-friendly interfaces, trustworthy advisory services and embedding local agricultural expertise. Two key aspects of assessing the impact of AI would therefore be its ability to aid farmers in adapting to the changing climate, reduce their exposure to conditions, and build their resilience over time.

Conclusion

AI is identified as one of the technologies that can support climate intelligent agriculture and increased farm vulnerability to climate change. Climate change uncertainty gave farmers a window of opportunity to make fast and effective decisions informed by artificial intelligence (AI) forecasting, predictive analytics, early warning systems and environmental monitoring and intelligent decision support. By predicting possible dangers and resource utilization, AI enables farmers to make proactive decisions, as well as to account for environmental fluctuations. The potential for artificial intelligence (AI) climate intelligence is therefore significantly greater if used in linking this information to decision making at the farm level and if used to build up greater climate resilience of agricultural systems.

Recommendations

The agricultural policy should make easier for farmers to access, affordable and locally available AI powered system of climate intelligence, to assist them in timely access to weather forecast, early warning, crop recommendations and climate risk information. Capitalise on the digital infrastructure and build the digital and technological competences of farmers, using training programmes of governments and agricultural extension agencies. AI platforms need to be developed based on information needs, farming systems, crops and local climate of the region. The improvement of accuracy and usability of AI-based advisory systems should be encouraged through cooperating between agricultural researchers, technology developers, meteorological institutions, extension services, and the farming community. There is a particular need to pay special attention to smallholder farmers, and to make technology less expensive and more easily accessible to them. Along with the practical experience of farmers, AI must be used alongside to make the technological recommendations functional and context-aware. Importance of transparency, data quality, privacy and human oversight should be placed more prominently to ensure the reliability and trustworthiness of agricultural systems powered by AI.

Future Directions

To explore the long-term effects of AI climate intelligence on farming adaptation and resilience, as well as other areas of agriculture, more longitudinal, experimental and comparative research designs will be required. Comparisons can be made on the basis of AI exposure between different farmers, and between different regions, crops, farm size, climatic conditions and among socioeconomic groups. Also other factors that might mediate or moderate the independent and dependent variables, such as digital literacy, technological trust, agricultural extension access, infrastructure, financial resources and institutional support should be explored in the future studies. Combining data from farm-management activities and surveys with satellite observations and data from IoT sensors and weather stations will enable more objective ways to understand AI-powered climate intelligence and resilience. Further, there is a need for localized AI models, multilingual advisory tools, and interfaces that can provide farmers with context-specific advisories in the future. By providing this information, the potential for long-term improvement in farm productivity, resource use efficiency, adaptation and resilience to climate change can be enabled using AI-based climate intelligence.

Conflict of Interest

The authors showed no conflict of interest.

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